SPECIFICATION

WATER ACTIVATED RELEASE TRIGGERING MECHANISM

BACKGROUND OF THE INVENTION

[0001] The field of the invention is an automatic release mechanism, and the invention relates more particularly to a water activated automatic release mechanism for a parachute harness.

[0002] U.S. Patent No. 5,857,247 issued January 12, 1999, for "Buckle System for Manual or Automatic Release of Crew Member Harness from Parachute" and assigned to the assignee of the present application, discloses a buckle system having many of the features of the present invention. The '247 patent is incorporated herein by reference for background purposes.

[0003] Combat aircraft often operate over water, and due to the role of such aircraft, crew members may experience a need to parachute from the aircraft. Such need may result from hostile fire in combat, from an accident, or due to equipment failure. The crew members may further experience injury prior to exiting the aircraft, during the exiting, or after the exiting. In some cases, a crew member may land in water in an unconscious or disabled condition. If the crew member should land in water, and is unable to release their parachute, the added weight and/or drag may pull the crew member below the water surface, and may result in further injury or drowning.

[0004] To prevent such further injury or drowning, known parachute harnesses include an automatic release mechanism. Such release mechanism includes at least two critical requirements.

First, that the mechanism has a high probability of correctly releasing the parachute if the crew member becomes immersed in water. Second, a near zero probability of false release. Generally, the crew member will be able to release the parachute, and therefore a failure of the automatic release mechanism to perform a correct release is generally not a critical event. Alternatively, a false release may be a fatal event.

[0005] The '247 patent teaches such release mechanism integrated internally into a buckle of the parachute harness. Although the release mechanism of the '247 patent provides the needed automatic release functionality, the release mechanism is not easily removed from the buckle for service, battery replacement, or to upgrade to a new release mechanism. Further, a new buckle system has been developed which requires a new automatic release mechanism. What is needed is an automatic release mechanism for the new buckle, which new automatic release mechanism may easily be removed for service, battery replacement, or to upgrade with a new release mechanism. Due to the extreme cost of a false release, there is also a need for false release events to have the lowest possible probability, while maintaining a reasonable probability of correct release.

BRIEF SUMMARY OF THE INVENTION

[0006] The present invention addresses the above and other needs by providing a water activated release triggering mechanism which is removably held to an exterior surface of a buckle housing and includes at least two probes, and at least two batteries distributed between independent paths, for firing a squib. The batteries are selected such that a single battery can not cause the squib to fire. Thus, the distribution of batteries between independent paths, combined with the power level of each

battery, precludes false firing from a single short with the housing of the release mechanism. The batteries may be soldered into the associated circuit, and may be easily tested through the probes. The triggering mechanism is designed to be impervious to Electro Magnetic Interference (EMI) and to preclude false fire in the presence of 20,000 volts of Electro Static Discharge (ESD). The release mechanism may further be designed so that immersion in fresh water, as in the case of exposure to rain, will not cause the squib to fire. The triggering mechanism may be easily removed for servicing, replacement, or for upgrading, and may be designed to allow the batteries to be easily replaced at a depot, or by return to the manufacturer.

[0007] In accordance with one aspect of the invention, there is provided a water activated release mechanism comprising a first probe exposed to the environment, a second probe exposed to the environment, at least one first battery having a first positive terminal and a first negative terminal, the first positive terminal electronically connected to a first node and the first negative terminal electrically connected to the first probe, at least one second battery having a second positive terminal and a second negative terminal, the second positive terminal electronically connected to the second probe and the second negative terminal electrically connected to the second node, and a squib electrically connected between the first node and the second node. The at least one first battery preferably comprises two three-volt batteries and the at least one second battery preferably comprises two three-volt batteries. The batteries are selected so that the combined output of all of the batteries is required to fire the squib. The batteries are preferably long life batteries, preferable small size, and preferably tolerant to low temperatures, and more preferably lithium batteries and most preferably part number CR1616. The at least one first battery and the at least one second battery may be

electrically connected through the first probe and the second probe (i.e., by joint immersion of the first probe and the second probe in salt water) to produce a positive voltage at the first node. The squib is preferably a one amp one watt squib and preferably provides a minimum force of approximately 100 lbs and a stroke of approximately 0.25 inches, and more preferably a part number P1590N actuator manufactured by Eagle Picher in Phoenix, Arizona. The squib may be embedded in a heat sink to inhibit false fire due to low power long term magnetically induced currents, and preferably the squib is electrically connected with a switch, the squib and switch being serially electrically connected between the first node and the second node. The probes may be any conductive material and preferably comprise gold cups. The probes are preferably located on opposite sides of the device housing and preferably approximately two to four inches apart. Alternatively, a single probe may electrically cooperate with the mechanism housing, buckle housing, or other suitable conductor.

[0008] The mechanism may further include a diode electrically connected between the first node and the second node, a cathode terminal of the diode electrically connected to the first node, an anode terminal of the diode electrically connected to the second node, a third node electrically connected between the anode terminal and the second node, a second resister electrically connected between the third node and the second node, and a lead electrically connecting the third node to a control gate of the switch. The switch is preferably adapted to remain open until the voltage on the first node is at least the breakdown voltage of the diode, at which event current flows through the diode to the third node and through the lead to close the switch. The diode is preferably a zener diode and more preferably a part number MA8091-H manufactured by Motorola. The second resister is preferably

selected based on the SCR gate current, and more preferably at least approximately a 10,000 ohm resister. The switch is preferably a Silicon Controlled Rectifier (SCR), and more preferably a part number MCR8DSM manufactured by Motorola.

[0009] The mechanism may further include a capacitance C electrically connected between the first node and the second node and a resistance R1 electrically connected between the first node and the second node. The capacitance C preferable comprised at least approximately 2.7 m Farad capacitance, and more preferably six approximately 0.45 m Farad capacitors, wherein the capacitance may be selected to deliver between 550,000 and 5,000,000 ergs of energy, and preferably, the capacitance C is selected to match the requirements of the squib. The resistance R1 is preferably comprises a 150-ohm thermistor having a negative temperature coefficient, in series with a fixed 350 resister. The resistance R1 may be selected to cooperate with the required conductivity across the water probes to establish a maximum charging voltage across the capacitance C

[0010] It is a further feature of the present invention to provide a water activated release mechanism comprising a first probe exposed to the environment, a second probe exposed to the environment, at least one battery electronically connected between the first probe and a first node, or the second probe and a second node, wherein the at least one battery is electrically connected to produce a positive voltage at the first node, a first resister electrically connected between the first and the second node, a capacitance electrically connected between the first node and the second node, a squib and a switch serially electrically connected between the first node and the second node, a diode having an anode terminal and a cathode terminal, the cathode terminal electrically connected to the first node, a third node electrically connected between the anode terminal and the second node, a second resister

electrically connected between the third node and the second node, and a lead electrically connected between the third node and a control gate of the switch.

[0011] It is an additional feature of the invention to provide a method for activating a release mechanism, the method comprising steps of closing a circuit between a first probe and a second probe, creating a positive voltage at a first node from a first battery electrically connected between the first probe and the first node, and from a second battery electrically connected between a second node and the second probe, charging a capacitor electrically connected between the first node and the second node, exceeding a breakdown voltage of a diode having a cathode terminal electrically connected to the first node, and an anode terminal electrically connected to a control gate of a normally open switch, wherein the switch and a squib are serially electrically connected between the first node and the second node, closing the switch, and firing the squib.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

[0012] The above and other aspects, features and advantages of the present invention will be more apparent from the following more particular description thereof, presented in conjunction with the following drawings wherein:

[0013] Figure 1 is a buckle with a release triggering mechanism attached;

[0014] Figure 2 is a top view of the release triggering mechanism;

[0015] Figure 3 is one embodiment of a circuit included in a release triggering mechanism;

[0016] Figure 4 is another embodiment of a circuit included in a release triggering mechanism;

[0017] Figure 5 is a preferred embodiment of a circuit included in a release triggering mechanism;

[0018] Figure 6 includes parallel plots of resistance and voltage values during operation of a release triggering mechanism; and

[0019] Figure 7 is a flow chart of a method of operation of a release triggering mechanism.

[0020] Corresponding reference characters indicate corresponding components throughout the several views of the drawings.

DETAILED DESCRIPTION OF THE INVENTION

[0021] The following description is of the best mode presently contemplated for carrying out the invention. This description is not to be taken in a limiting sense, but is made merely for the purpose of describing one or more preferred embodiments of the invention. The scope of the invention should be determined with reference to the claims.

[0022] A harness buckle mechanism 10 including a buckle housing 12, a strap holder 14, and a water activated release triggering mechanism 16 is shown in Figure 1. The triggering mechanism 16 is removably held to an exterior surface of a buckle housing, and preferably held to the surface which rests against a human body when the harness is in use, thus cushioning the triggering mechanism 16 against impacts. The triggering mechanism 16 is attached to the buckle housing 12 so as not to affect the load path of the parachute harness. The triggering mechanism 16 includes a housing which is preferably solid and preferably made from aluminum. The triggering mechanism 16 may be sealed to protect the elements with the triggering mechanism 16 from the environment.

[0023] A top view of the triggering mechanism 16 is shown in Figure 2. A mechanism window 18 allows an arm, level, or other mechanical member of a buckle mechanism 10 to extend into the

triggering mechanism 16 to mechanically cooperate with the triggering mechanism 16. In other embodiments, an arm or other mechanical element may protrude from the triggering mechanism 16 to provide cooperation with a buckle mechanism, or the triggering mechanism may be integrated into a buckle mechanism, and these other embodiments are intended to come within the scope of the present invention. The triggering mechanism 16 further includes four screw passages 20 to facilitate removal and replacement of the triggering mechanism 16. The triggering mechanism 16 may be attached to the buckle housing 12 by various other attachment methods, for example more or less than four screws, cooperation of features of the triggering mechanism 16 and features of the buckle housing 12, pop rivets, or the like, and a triggering mechanism 16 attached by any other method is intended to come within the scope of the present invention.

[0024] The triggering mechanism 16 is an electro-mechanical device which includes a circuit for detecting the immersion of the device in water, and preferably immersion of the device in sea water. A first example of a circuit for use in the triggering mechanism 16 is shown in Figure 3. The circuit includes a first probe P1, and a second probe P2, with water conductivity path 32 between the probes P1 and P2. The probes are preferably gold cups, and are preferably on the exterior of the triggering mechanism 16 approximately two to four inches apart and on opposite sides of the trigger mechanism 16. In other embodiments, the probes may be in recessed in the triggering mechanism, or the probes may be distally located from the triggering mechanism 16 and electrically connected to the triggering mechanism by probe leads, and such embodiments are intended to come within the scope of the present invention. A first battery B1 is electrically connected between the probe P1 and a squib 26, and a second battery B2 is independently electrically connected between the probe P2 and the squib

26. A piston or actuator 28 resides in the squib 26, and when the squib 26 fires, the piston 28 is pushed against a member 30 which initiates the release of the buckle. By placing the batteries in independent paths, a single short between a path or a probe and the triggering mechanism 16 housing can only provide half the required energy to the squib 26, thus preventing a false fire.

[0025] A second example of a circuit for use in the triggering mechanism 16 is shown in Figure 4. In many cases, the triggering mechanism 16 must operate in a highly electromagnetically active environment without false firing. Is such environment, even a short wire may act as an antenna and produce current flow within a circuit. In order to preclude false fires in such environments, a one watt one amp squib is preferably used. Additionally, the circuit may be designed to be impervious to Electro Magnetic Interference (EMI) and to preclude false fire in the presence of 20,000 volts of Electro Static Discharge (ESD).

[0026] The second circuit includes at least one battery B1 to create a positive voltage at a first node N1. The battery B1 is preferable electrically connected between the first probe P1 and the node N1, and may alternatively be electrically connected between a second node N2 and the second probe P2. Preferably, the battery comprises two independent batteries, with a first battery electrically connected between the probe P1 and the node N1, and a second battery electrically connected between the probe P2 and the node N2, and more preferably two independent batteries serially electrically connected between the probe P1 and the node N1, and two independent batteries serially electrically connected between the probe P2 and the node N2, which batteries are connected to contribute to a positive voltage at the node N1. A capacitor C is electrically connected between the node N1 and node N2. A first resister R1 is connected between the nodes N1 and N2 in parallel with the capacitor C, to

calibrate the conductivity . The squib 26 and a switch M are serially electrically connected between the nodes N1 and N2, and a first diode D1, a third node N3, and a second resister R2 are serially electrically connected between the nodes N1 and N2, wherein the node N3 is electrically connected between the diode D1 and node N2, and the resister R2 is connected between the node N3 and the node N2. The cathode terminal of the diode D1 is electrically connected to the node N1, and the anode terminal of the diode D1 is electrically connected to the node N3. A lead L electrically connects the node N3 to a control gate on the switch M.

[0027] When the probes P1 and P2 are immersed in sea water, the resistance between the probes P1 and P2 drops and current flows into the capacitor C. Initially, the diode D1 prevents current flow to the node N3, and the switch M remains open, thus preventing current from flowing through the squib 26. When the voltage across the capacitor C (i.e., the voltage between the nodes N1 and N2) reaches the breakdown voltage of the diode D1, current flows through the diode D1 to the node N3, and through lead L to the switch M. The switch M closes, and current flows through the squib 26, causing the squib 26 to fire. The piston 28 is pushed against the member 30 which initiates the release of the buckle.

[0028] In other embodiments, an analog or digital circuit may monitor the voltage Vc across the capacitance C, and compare Vc to a threshold voltage Vt. If Vc reaches or exceeds Vt, a signal may be sent to the switch M to close the circuit through the squib 26. Such other embodiments are intended to come within the scope of the present invention.

[0029] A preferred embodiment of a circuit of the release mechanism is shown in Figure 5. Two batteries B2 are serially electrically connected between the node N2 and the probe P2. Two additional

batteries B1 are serially electrically connected between the node N1 and the probe P1. The batteries B1 and B2 are preferably long life cells, and more preferably lithium batteries, and most preferably CR1616 batteries. Two resisters R3 and R4 are serially electrically connected between the nodes N1 and N2. The resister R3 is preferably a thermistor, and more preferably a 150-ohm thermistor having a negative temperature coefficient, to allow the circuit to adjust to different operating temperatures. The resister R4 is preferably a 350 ohm resister. A capacitance C is also electrically connected between the nodes N1 and N2, which capacitance C is preferably an approximately 2.7 m Farad capacitance, and more preferably six approximately 0.45 m Farad capacitors, and most preferably part number TPSE477K01R0050 made by Commonwealth Sprague located in North Adams, Massachusetts.

[0030] A second diode D2, third node N3, and a second resister R2 are serially electrically connected between the nodes N1 and N2, wherein the node N3 is electrically connected between the diode D2 and node N2, and the resister R2 is connected between the node N3 and the node N2. The cathode terminal of the diode D2 is electrically connected to the node N1, and the anode terminal of the diode D2 is electrically connected to the node N3. The diode D2 is preferably a zener diode, and more preferably (specs for zener diode?) And most preferably part number MA8091-H manufactured by (name, city, state).

[0031] The squib 26 (Figures 3 and 4) is represented by an equivalent resistance R5 which is serially electrically connected with a Semiconductor Controlled Rectifier (SCR) between the nodes N1 and N2. The SCR is preferably a part number MCR8DSM manufactured by Motorola. A lead L

electrically connects the node N3 to a control gate on the SCR. A circuit thus configured provides substantially all the advantages of the circuits described in Figures 3 and 4.

[0032] The operation of the circuit of Figure 5 may be more easily ascertained from reviewing Figure 6. The top plot shows the resistance Rp across the probes P1 and P2. Prior to immersion in sea water, the resistance Rp is very high, and effectively zero current flows between the probes P1 and P2. At time T1, the probes are immersed in sea water, the resistance Rp drops to approximately100 ohms for 10,000 micromhos conductivity, and current flows between the probes P1 and P2, creating a positive voltage at node N1. The middle plot shows the voltage Vc across the capacitor C, which is also the voltage between the nodes N1 and N2. The voltage Vc is initially approximately zero volts. At time T1, the capacitor begins to charge, and the voltage Vc begins to rise. Initially, the diode D2 prevents current from flowing to the node N3. At time T2, the voltage Vc reaches the breakdown voltage of the diode D2 and current flows to the node N3, to the control gate of the SCR, and the SCR closes the circuit through the squib 26 (or equivalent resistance R5). Starting at T2, voltage Vs flows through the squib 26, and the resulting energy 34 builds in the squib 26. At time T3 the energy raises the temperature sufficiently to fire the squib 26.

[0033] A method according to the present invention is shown in Figure 7. The circuit between the probes P1 and P2 is closed at step 40. The resulting current flow creates a positive voltage at node N1 at step 42. The voltage at node N1 causes the capacitor C to charge at step 44. When the voltage Vc across the capacitor C reaches the breakdown voltage of the diode D2 at step 46, current flows to the node N3, and to the switch, causing the switch to close at step 50. Current then flows through the squib 26, and the squib 26 fires at step 52.

[0034] The circuits described above, may alternatively be expressed based on the relationship of the circuit elements. Beginning with water actuation, the conductivity (resistance) of the water that the unit is intended to function in is the starting point for the design. Very fresh water, such as from a household tap, has 100 to 1000 micro-mhos conductivity. Sea water, on the other hand, has values of 10,000 to 40,000 micro-mhos conductivity. These conductivity values equate to water resistance of 10,000 to 1000 ohms for fresh water and 100 to 25 ohms for sea water. This resistance appears between the water probes when the unit is immersed in water. Referring to Figure 3 above, these conductivity values apply to path 32. There is thus formed a series circuit B1/R1/path 32 with voltage divided between R1 and 32. Thus, the value for R1 may be selected based on the voltage is required to fire the selected squib 26.

[0035] For example, the squib 26 may require 5 volts to fire. If the voltage drop across the switch (M), when it is turned on, is .5 volts, a safety margin is desirable to guarantee that the squib 26 will fire when required. A fifty percent safety margin is preferred for the squib 26 firing voltage. Adding these voltages (5.5 volts + 2.75 volt safety margin) results in 8.25 volts. The capacitor C is the source of the firing voltage, and as a result, the switch M preferably triggers when there is 8.25 volts across the capacitor C. A zener diode may be selected that triggers the switch M at approximately 8.25 volts. When the voltage on the capacitor C exceeds 8.25 volts, the switch M turns on and provides 8.25 volts across the squib 26. The value of the resister R1 may be calculated such that the voltage across resister R1 in the R1/path 32/B1 series circuit is greater than the required 8.25 volts. The voltage across the resister R1 is the voltage that the capacitor C will charge toward.

[0036] For example, if the voltage B1 is 20 volts, the water is 10,000 micro-mhos, and the resistance of path 32 is 100 ohms, a preferred resistance R1 is approximately 300 ohms. The result is 15 volts across resister R1. When immersed in water, the capacitor C will begin to charge toward 15 volts. When the capacitor C reaches 8.25 volts, the switch M turns on (opens) and the capacitor C discharges through the squib 26 causing the squib 26 to fire.

[0037] Alternatively, if the resistance R1 is 100 ohms and B1 remains 20 volts, the capacitor C charges toward 10 volts. As a result of the lower charging voltage, the capacitor C will take longer to charge to 8.25 volts. Further, if the water conductivity changes, the resistance of path 32 changes. If the water resistance changes to 3,333 micro-mhos (300 ohms), and the resistance R remains 100 ohms, the result is 5 volts across the resister R1, and the capacitor C will charge toward 5 volts maximum. In this instance, even if the capacitor C is fully charged (i.e., to 5 volts) there is not enough voltage to fire the squib 26. Thus, the circuit may be designed to fire the squib when immersed water having the desired conductivity, or to obtain a desired delay time to firing the squib 26, and a circuit having the basic architecture described above, and including circuit components selected according to these constraints is intended to come within the scope of the present invention.

[0038] While throughout the above description, the use of batteries as a power source had been described, other power sources may be substituted, and a mechanism using another power source is intended to come within the scope of the present invention.

[0039] While the invention herein disclosed has been described by means of specific embodiments and applications thereof, numerous modifications and variations could be made thereto by those skilled in the art without departing from the scope of the invention set forth in the claims.